ASD TR 7-904 (VII)

ASD INTERIM REPORT 7-904 (VII)

STRUCTURAL FABRIC PROGRAM

J. O. Miller
E. Bilsky

GOODYEAR AIRCRAFT CORPORATION
Akron 15, Ohio

Contract: AF33(600)43036
ASD Project: 7-904

Interim Technical Progress Report
1 January 1963 to 31 March 1963

The purpose of this program, as related to aerospace applications, is to provide a means of manufacturing large low-density AIRMAT structures made of metallic cloth and yarns capable of small volume packaging.

METHODS AND MATERIALS DIVISION
MANUFACTURING METHODS DIVISION

Aeronautical Systems Division
United States Air Force
Wright-Patterson Air Force Base, Ohio

GOODYEAR

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AKRON 15, OHIO

ABSTRACT - Summary

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The purpose of this program, as related to aerospace application, is to provide a means of manufacturing large low-density AIRMAT* structures made of metallic cloth and yarns capable of small volume packaging.

The work reported herein was accomplished during the seventh quarterly period under contract AF33(600)-43036. During this period, the loom design was finalized and fabrication of the major portion of the loom parts and assemblies was completed. The design of the take-off mechanism was completed and fabrication was underway. A site for the loom was selected and preparations are underway for loom installation.

The aforementioned efforts are directed toward the development of a loom procurement specification and the actual procurement of a loom capable of producing a low-density AIRMAT in the order of 20 feet wide with a maximum depth of 8 feet.

*T.M. - Goodyear Tire and Rubber Company

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FOREWORD

This Interim Technical Progress Report covers the work performed under Contract AF33(600)-43036 from 1 January to 31 March 1963. It is published for technical information only and does not necessarily represent the recommendations, conclusions, or approval of the Air Force.

This contract with Goodyear Aircraft Corporation was initiated under ASD Manufacturing Methods Project 7-904 "Structural Fabric Program". It is administered under the direction of Mr. J. O. Snyder, ASRCFT, of Methods and Materials Division, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. This report is the seventh in a series to be published quarterly for the duration of the contract.

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SECTION I - INTRODUCTION

The glide re-entry vehicles presently being designed require large low-density structures. The use of fabrics for the structural material not only answers this requirement but provides the advantage of being packageable in a small volume for ease of storage and handling on the ground with the additional advantages of maximum utilization of missile payload volume and minimum effect on the aerodynamic performance of the missile during ascent. The rapid pace of development in the astronautics field imposes the requirement that facilities, capable of producing quantities of fabrics for re-entry applications, be available in the near future. Goodyear Aircraft Corporation (GAC) is now engaged in a program under Contract AF33(600)-43036 to develop a loom and associated machinery and processes capable of producing metallic AIRMAT fabrics of such size, quality, and shape as required for re-entry vehicle applications. This report concerns itself with the effort during the seventh quarterly period under Contract No. AF33(600)-43036.

The ultimate objective of this program is a loom having the capabilities of weaving large AIRMAT structures. These capabilities will be demonstrated by weaving AIRMAT specimens in two (2) categories.

1. Type 304 stainless steel flat AIRMAT, 11 feet wide, 8 feet thick by 5' long (warp direction), 100 picks by 100 ends per inch.

2. Type 304 stainless steel contoured AIRMAT, 20 feet wide and 10 feet long with a cross section along the 20 foot fill direction consisting of 6 foot straight AIRMAT, 4 feet deep with the remaining 14 feet having an upper and lower parabolic contour tapering from 4 feet to 6 inches in depth. This specimen will have a 20% slope along the 10 foot length (warpwise). The specimen will have 100 picks by 100 ends per inch.

It is also intended that the loom shall have the capability of weaving shapes such as open end tubes, cones of different angles and curved surfaces of different radii of curvature such as ellipses and parabolas.

SECTION II - DISCUSSION

A. Work Complete During the Seventh Reporting Period

1. General Loom Design and Fabrication

The manufacturing drawings are now complete except for a few which are not presently required and which will be completed as the erection of the loom progresses. With the final assembly and erection of the loom to be completed soon, it became necessary to determine the colors which the loom is to be painted. It is presently proposed that the colors and color coding system as shown in Table I will be applied to the Structural Fabric Loom. These colors will be applied as shown except in areas where operational visibility is found to be a problem, due to shadows, reflections etc. Colors for areas such as these will be determined by GAC to provide for maximum visibility and minimum hazards.

TABLE I

LOOM COLOR CODING

a. Basic Loom Accessories & Special Equipment . . . Blue-Green

b, Parts of a hazardous nature . . . . Orange

Hazards that can crush, cut, shock, or burn such as electrical controls and unguarded dangerous moving parts.

c. Intermittently operated exposed parts . . . . . Orange stripes or bands

Exposed flywheels, clutch and brake housings, etc. which operate intermittently and constitute a safety hazard will be striped or banded so as to change color when set in motion.

d. Protruding parts, stands, tools or fixtures . . Yellow

With the adoption of the present final loom configuration, it was decided to provide a sectional stainless steel reed. Each reed section will be 36 inches long by 12 inches high and will contain

33 1/3 dents per inch. A subcontract was awarded to the Steel Heddle Company, Philadelphia, Pennsylvania to design and fabricate the reed.

The Steel Heddle Company would not guarantee a satisfactory reed beyond 33 1/3 dents/inch for a 12 inch high reed. It is their feeling that beyond this limit, the dents will not maintain their rigidity and may collapse against each other which would impede the shedding movement of the yarns through the dent. It was pointed out that a finer reed may be possible by soldering alternate dents to maintain rigidity. This would markedly increase the cost of the reed and also limit distribution of the pile yarns to only those dents that were not soldered. Based on the fact that it would not be possible to reduce the dent size because of the size of the movable and fixed gages that must pass through the reed along with the higher cost and limited distribution of pile yarns, it was decided to accept the 33 1/3 dent reed as being the most practical size for the Structural Fabric Loom.

2. Weft Insertion

Since the beginning of this program, consideration has been given to many different methods of weft insertion including shuttles, rapier and flexible inserters with package pickups and different methods of single weft insertions. During the preliminary design concept phase and the early experiments with intraweave, it was thought that a flexible weft inserter would be required to permit contour weaving (see ASD Interim Report 7-904 II, Page 16). With the abandonment of the intra-weave technique and the subsequent adoption of the mechanical drop yarn extension technique, the need for a flexible type inserter disappeared and a decision was made to adopt a rapier type inserter capable of inserting a single weft. This was specified in the Structural Fabric Loom Specification.

The following is the results of an evaluation of the three methods of weft insertion considered to be applicable to the loom:

a. Weft thread pick-up by each insertion from stationary packages located on left side of weave. A single strand of weft is pulled into each shed by each inserter and the end is released on right side of weave.

Advantages

1) Weft supplied from large stationary package, theoretically making for more continuous operation of the loom.

2) Single strand of weft laid in shed for plain "one-shot" weave pattern.

Disadvantages

1) Due to precise timing and positioning of stationary and traveling clamps and release mechanisms, system will necessitate a development time period during the initial weaving trials to perfect the mechanism to a reliable level.

2) Clean selvage edges are not formed by this weaving process. The weft ends must be trimmed after insertion if dangling excess weft is found objectionable to weaving process.

b. Weft package pick-up system similar to system designed by Lansco and being used by GAC on their 60" loom. Single continuous weft laid in each shed by inserter alternately picking-up and depositing package on left side of loom.

Advantages

1) Continuous single strand of weft laid in shed for plain one-shot weave pattern.

2) Clean selvage edges are inherent with this weaving process.

Disadvantages

1) Loom must be stopped after predetermined number of picks to replenish the weft package.

2) Weight and size of weft package is a factor in design to insure minimum loading on inserter and drag through the shed.

c. Weft needle inertion system. Double strand of weft permanently threaded through eye at leading edge of inserter is carried through weave to left side where selvage shuttle or bobbin engages weft loop. (Sewing machine principle.)

Advantages

1) Continuous double strand of weft pulled into shed, supplied from large stationary package.

2) Higher production rate (100% increase) is obtained by inserting two instead of one weft strand at a time.

3) Produces a clean selvage on both sides of fabric.

4) Can be used for textiles as well as wire weaving.

5) The principles of this mechanism design have been established and are presently in practice on carpet looms.

6) Easier to time and operate than single end pickup.

Disadvantages

1) Weft feed-up velocity is twice that of other systems.

2) Double weft.

As a result of this evaluation, it was decided to adopt the needle type weft inserter since it offers the most advantages and would improve the loom capabilities by permitting the weaving of textile yarns in addition to wire. It was also felt that since the loom already includes so many mechanisms of new design, it would be advisable to make use of a tried and proven weft inserter.

The drive for the inserter mechanism will be so designed that if at a later date, a package pick-up or single end inserter is desired a minimum of changes would be required.

The high weft feed-off velocity effect will be minimized by proper design of the weft supply package and the effect of the double weft can be easily overcome, if required, by the use of a weft yarn of smaller diameter which can reduce the total area of the double weft to that of a single weft.

3. Warp Beams

After the first of the cast aluminum warp beam was machined, it was found that some gas porosity had occurred in the beam casting (see Figure 1). Since the porosity would have no adverse affect on the structural properties of the beam, it was determined that an epoxy filler could be added to eliminate any possibility of snagging the warp yarn during beaming or let-off. When the foundry was contacted and advised of the porosity, they agreed to try to minimize the porosity in the balance of the warp beam castings. The second and third beams showed improvement but still required some filling. It is thought that subsequent beams will require only a thorough polishing of the yarn contact surfaces to prevent yarn snagging. All beams will be inspected by rubbing the yarn contact surfaces with a bundle of yarn to determine if snags exist.

4. Warp Heddle Wires

The specification for the warp heddle wires was changed from stainless steel to double nickle plated carbon steel to improve the delivery and reduce costs. The double nickle plated carbon steel heddle wires are normally used in both textile and wire weaving looms.

5. Creels

The design for the creels was completed and fabrication was started during this quarter. A question arose from the last Interim Technical Report (7-904 VI) concerning a possible tangling situation which was thought might occur as a result of hanging the tensioning weights on the wire yarns. It has been found in GAC's experience on the 60 inch experimental loom that no tangling problems have occurred when using hanging weights on wire or textile yarns. The proposed method of tensioning by using pigtail U weights of various sizes is much more economical and more trouble free than other methods of tensioning when operating with the speeds and yarn sizes as planned for the Structural Fabric Loom.

FIGURE 1

POROSITY IN CAST ALUMINUM WARP BEAM PRIOR TO FILLING PROCESS

6. Drop Yarn Extension Mechanism

The final design configuration for the Drop Yarn Extension was established during this quarter. To arrive at this decision, a considerable effort by both Lansco and GAC was expended to solve the extension mechanism problems. The main areas in question were the pile wire configuration, means of pile wire retention after extension and the means moving the pile wires along with the fabric, all of which are aimed at reducing, to a minimum, the chances of tangling of drop yarns when the finished Airmat is in the take-off mechanism. Various configurations for the pile wire were considered along with various means for the pile wire retention and traverse, such as notched racks, toothed bands, sewing machine type gripper feet, spiked tape etc. However all these methods applied only to the outside edges of the wire whereas it was decided that it would also be necessary to grip the wire at intervals throughout its length to prevent sagging and misplacement with resulting drop yarn entanglement. It was finally determined that a hook system within the Airmat to maintain the contoured position of the pile wires to be used in conjunction with a soft aluminum pile wire seem to be most logical for the application. The various basic areas of the Drop Yarn Extension will be designed essentially as noted below:

a. Pile Wires

The pile wires will be made from round aluminum stock (approximately 3/16 inch diameter) which will provide sufficient rigidity to extend the drop yarns in conjunction with the capability to take a permanent set to facilitate Airmat removal In the present design concept of the extension mechanism, the pile wires will be cut to length to suit the Airmat width being woven. The pile wire head and tail will be formed by bending the wire into a desired shape.

b. Pile Wire Inserter Drive

The drive mechanism for inserting the pile wires will be independent from the loom drive and will be programmed to insert a pile wire after a predetermined number of picks while the loom is stopped.

The driving mechanism will consist of a $1\frac{1}{2}$ HP variable speed drive through an electric clutch and brake unit which rotates the crank drum one complete revolution only and then is automatically de-energized. The crank stroke oscillates the cable drum which, through its cables, pulls the pile wire hopper across the wire table and back to its original "out" position. Before the hopper reaches its full "out" position, a cam rotates a cylinder loaded with pile wires so that a pile wire is positioned in front of the hopper in preparation for a repeat of the insertion cycle after a predetermined number of picks.

c. Extension Gages

The extension gages will be spaced at intervals of 6 inches across the loom width providing a total of 42 gages, which is felt will be adequate to extend and control the pile wires when weaving either flat or contoured Airmat. The extension gages will travel in guard gages which are provided to protect the drop yarn from damage and wear. A 3/64 inch diameter steel cable will be attached to the front end of each gage and to the contouring mechanism. A nylon coated steel cable will be attached to the rear end of each gage and will be connected to a pulley weight system located in the rear of the loom in front of the warp beams. The function of the weight system in the rear of the loom is to tension the gages while they are being driven forward or backwards by the contouring mechanism.

d. Pile Wire Traverse and Retention

After the contouring gages bring the pile wires to the forward extended position, a series of bands with teeth engage the pile wires, hold them in position and move them forward as the Airmat progresses on the take-off mechanism. The bands, similar to band saw blades are connected to the take-up bar and pass through the reed and harness frames to a position near the warp beams. Here are located the individual feed off drums, each with a capacity of approximately 100 linear feet of band. As noted above, the purpose of the band teeth is to engage and hold the pile wires in their relative extended positions between the woven warp sheets and to take the pile wires out of the weaving area at the same rate as the woven warp sheets. By performing these functions, the extended drop yarn (which is woven around the pile wires) will be more likely retained in a tensioned and controlled condition, thus diminishing breakage and yarn entanglement possibilities.

A fixed flat gage on each side of the bands will be provided to protect the yarn.

The bands will be made from .014 inch x .625 inch spring steel and used at 24 inch intervals across the weave, with provision for 12 inch intervals if found necessary during the weaving trials. The bands will be attached to the drawbar which provides the motive power.

e. Programming Mechanism

As noted in last quarter's report, the loom will be provided with a programming mechanism as a means of controlling the position of the pile wire during drop yarn extension.

After a pile wire has been inserted into the shed by the inserter mechanism the programmer will be energized. The programmer contains a line shaft which is driven by a 3 HP motor through a variable pitch pulley, an 8 inch electric clutch and brake unit and a gear reducer box. The line shaft in turn drives seven 36 inch long clutch shafts. Keyed to each 36 inch long shaft are the magnets of six 4 inch diameter electric clutches. A pinion fastened to the clutch armature of each of these clutches meshes with 72 inch long gear racks. To each rack is fastened the 3/64 inch diameter steel cables from the movable gages mentioned above.

Also driven by the line shaft is a detection switch assembly which moves in a vertical direction above a one-quarter scale model of the specimen being woven. The switch assembly consists of an electrical switch for each of the 4 inch electric clutches and plungers for engaging the model. The model is also driven by the main line shaft through a single revolution clutch and change gear set-up. The linear advancement of the model is predetermined to conform with one quarter of the linear take-off of the fabric. The line shaft will move the detector switch plungers down to the model. As the plungers engage the model contour, their switches will progressively energize the 4 inch clutches, thus moving the racks and the corresponding contouring gages forward. The gages are continued to be pulled forward until an auxiliary switch mounted on the downward moving detector assembly engages the base line of the model, whereupon the 8 inch driving clutch is de-energized and the brake is energized. The auxiliary switch also re-energizes the main loom drive. After a predetermined number of picks, during which the extended drop yarn is woven into the fabric while the gages are holding the extended yarn, the loom energizes the extension mechanism motor in the reverse direction. Thus the gage racks, the gages, and the detector assembly are returned to their original position in preparation for another pile wire insertion.

During this reverse direction period, the single revolution clutch is engaged to index the model forward the proper amount in preparation for another detecting operation.

7. Drop Yarn Delivery Mechanism

A number of methods of drop yarn delivery were investigated until a concept was tentatively adopted which provided for a roll arrangement for pre-feeding the pile yarn which was to be installed between the loom beams and the creels. This method provided for a roll to be lowered on the pile yarn sheet displacing the yarn from the horizontal to a level equal to one-half the Airmat height. At time of pile yarn extension, two additional rolls or some similar yarn holding device would hold the pile yarn sheet in place and the displaced roll would begin to rise permitting the displaced yarn to be delivered to the mechanical extension at a minimum of tension. The holding rolls would then release and the yarn displacing roll would again begin a gradual descent during the regular weaving of the pile yarn and be in a position for providing low-tension pile yarn for the next extension.

During the past quarter, further investigations were conducted which brought about the adoption of a new concept which, it was thought, would improve wire delivery and reduce cold working possibilities.

This new method consists of a beater mounted over the drop yarn between the creel frames and the warp beams. The function of the beater is to swipe the drop yarn forward during the drop yarn extension operation to reduce tension caused by the force required to rotate the yarn spools. The beater is made in a 9 and a 12 foot section, chain driven from a 2 HP motor with variable pitch pulley and belt arrangement. The beater will be programmed to rotate only during that portion of the weaving cycle that drop yarn is being extended by the contouring mechanism at the front of the loom.

8. Wire Yarn

As a result of the decision to weave both contract specimens from .003 inch diameter, type 304 stainless steel, monofilament wire and the final determination of the specimen configurations it becme possible to calculate the quantity of wire required to weave both specimens. A total of 428 pounds of wire was ordered from Fort Wayne Metals Inc., Fort Wayne, Indiana to be shipped as shown below:

a.	220 spools @ 0.9 lb	=	198 lbs.
b.	20 spools @ 2.0 lb	=	40 lbs.
c.	335 spools @ 0.2 lb	=	67 lbs.
d.	410 spools @ 0.3 lb	=	123 lbs.

The wire in Item (a) will be used for warp. The wire in Item (b) will be used for weft. The wire in Items (c) and (d) will be used for pile. All spare wire may be used for weft.

9. Warping and Draw-In

Early in the Structural Fabric Program it was determined that it would be more economical and less time consuming to warp the beams and draw-in the warp through the harnesses and reed outside the loom and install the draw-in upper and lower warp as a unit. Consequently the loom was designed to provide for the removal and re-installation of the upper and lower warp beams, harnesses and reed, completely draw-in as a unit.

During this quarter, quotations were requested from a number of companies specializing in wire weaving. A sub-contract was subsequently awarded to the Lindsay Wire Weaving Company, Cleveland, Ohio. Lindsay has had previous experience on a job of this type, having warped and draw-in .0045 stainless steel monofilament yarn for GAC's 60 inch experimental loom.

In preparation for this effort, GAC designed and built a set of beam and harness stands (see Figure 2). These stands will provide a support for the beams, harnesses and reed in their relative

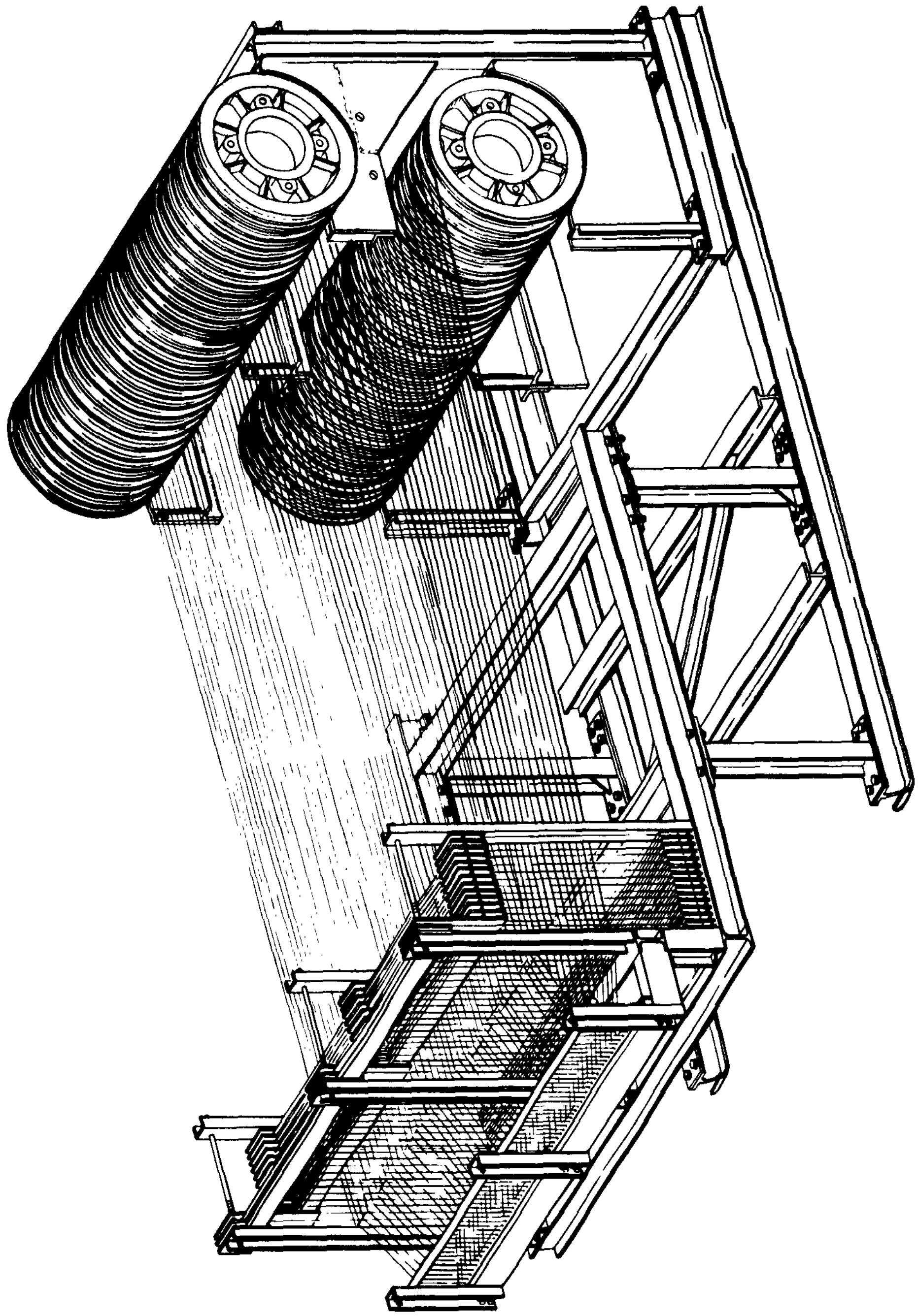

FIGURE 2

BEAM AND HARNESS STAND

loom positions during both beaming and draw-in, and will serve as a shipping skid plus an installation fixture. Three (3) 6 foot stands and one (1) 3 foot stand are provided to accommodate the 21 foot width of the loom. The 3 foot stand will accommodate two-3 foot warp beam sections, one above the other and three foot sections of the harnesses and reed. The 6 foot stands will accommodate four 3 foot warp beam sections, two up and two down plus 6 foot sections of the harnesses and two 3-foot sections of reed. The total warp width will be 244 inches, top and bottom, and will consist .003 inch diameter type 304 stainless steel monofilament, 200 ends per groove (100 mesh) with a warp length of 150 feet.

It is estimated that 3 months will be required to complete the warping and draw-in outside the loom. After receipt of this warp at GAC, it is estimated that one (1) week will be required to install the warp in the loom.

a. Warping

The stands will be numbered one through four inclusive starting with the left side of the loom. Numbers one through three are 6 foot stands and number four is a 3 foot stand. Two shaft supports will be provided plus one 3 foot shaft and one 6 foot shaft. To warp a beam section, the proper length shaft is inserted through the beam section(s) and through the two shaft supports which are mounted on each side of the stand. A jack screw on each shaft support containing a shaft bearing permits the beam section(s) to be elevated and free to rotate. A pully is attached to the shaft through which the motive power to drive the beam section(s) is transmitted.

b. Drawing-In

There will be 12 double row harness frames on each stand containing warp heddles. Harness frames 1 through 6 (in front) contain the heddles for the bottom warp, while harness frames 7 through 12 contain the heddles for the top warp. The drawing-in pattern is a straight draw (see Figure 3) starting at the left side with the first end in the top warp drawn through the first heddle on the front row of the number 7 harness frame. The next end to be drawn-in is the first end in the bottom warp beam. This is drawn-in through the first heddle on the front row of the number 1 harness frame. The drawing-in continues, alternating yarns from the top and bottom beams. The pattern switches to the back row of each

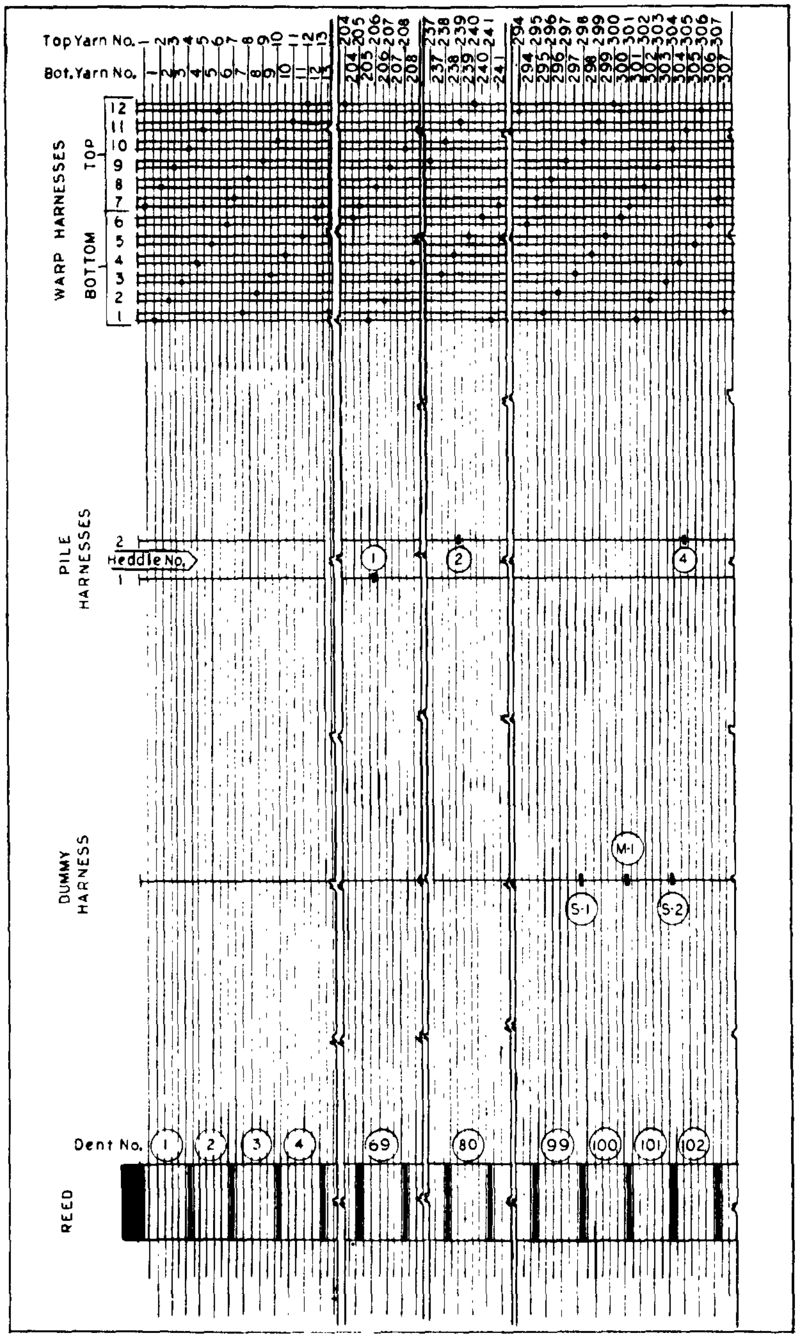

FIGURE 3
DRAWING-IN DIAGRAM

harness frame after 6 ends from each beam have been drawn-in. The cycle repeats after 12 ends from each beam have been drawn-in. There are a total of 14,400 ends (7200 x 2) in each beam and harness stand No. 1 through 3. In beam and harness stand No. 4 there are only 5600 (2800 x 2) ends.

There are also two single row harness frames containing the pile heddles. The pile heddles are placed between the ends of the upper and lower warps, with 33 ends from each warp (total of 66 ends) between each pile heddle after the placement of the first heddle at the left side of each beam and harness stand. The placement of the first heddle in each frame is according to the following schedule. If the pile heddle number is odd, it is placed on the front pile harness frame. The even pile heddle numbers are placed on the back pile harness frame.

The reed is drawn-in with 3 ends from each warp (total 6 ends) in each reed dent starting with the first dent at the left side in each beam and harness stand. There are 2400 reed dents in each of the first three (6' 0") beam and harness frames. There are only 1200 reed dents in the No. 4 (3' 0") beam and harness stand. The end of the warp occurs with one end from each warp in dent number 8134 in the No. 4 beam and harness frame 8 inches from the right hand end of the reed.

The movable gage heddles are positioned on the dummy harness frame, between the warp yarns, at reed locations, as follows:

Stand #1 - Reed dent No. 100, 300, 500, 700 etc. to dent No. 2300

Stand #2 - Reed dent No. 2500, 2700, 2900, 3100 etc. to dent No. 4700

Stand #3 - Reed dent No. 4900, 5100, 5300, 5500 etc. to dent No. 7100

Stand #4 - Reed dent No. 7300, 7500, 7700, 7900 etc. to dent No. 8300

These movable gage heddles are placed to the right of the warp yarns located in the above dent numbers.

Two stationary gage heddles are provided for each movable gage heddle and are located directly adjacent to each side of the movable gage heddle (or above reed dent number).

10. Automatic Tie-In and Draw-In Equipment

Upon considering the costs and delays involved in tieing in a new warp on the GAC 60" loom and/or the Structural Fabric Loom, an investigation is currently being made to determine the feasibility of employing automatic tie-in or draw-in equipment for these looms. Although there is no provision in the Structural Fabric Program for such equipment, the time and cost reduction provided by automatic equipment would enhance the overall capabilities of the AF loom. Evaluations are presently in hand to determine if this equipment can be adapted and what the limitations of present equipment are with regard to tieing in different warp materials (i.e. wire to wire, wire to Dacron etc.).

11. Take-Off Mechanism

During this quarter, although the design effort was temporarily halted in order to provide design assistance to Lansco in the design of the pile wire rack mechanism, the design of the take-off mechanism was completed. The fabrication of parts is approximately 20% complete.

12. Loom Site at GAC

A location for the installation of the loom has been selected which is at GAC's Wingfoot Lake Facility. (See Figure 4) This facility is located approximately 8 miles from GAC's main plant at Akron, Ohio. The building chosen to house the loom can be seen as the round top building located adjacent to the large airship hangar. This building will be devoted entirely to the development of woven inflatable materials both metallic and textile types. In addition to the Structural Fabric Loom, GAC's 60 inch experiment loom, yarn twister, all other allied cloth and Airmat producing equipment will be installed there.

B. Program for Next Quarter - April 1963 through 30 June 1963

1. During the next quarter, it is planned that the loom will be completely assembled, tested at Lansco, packed and prepared for shipment to GAC.

2. The operation and maintenance manuals will be prepared by Lansco and delivered to GAC.

3. The site location at GAC's Wingfoot Lake Facility will be completely readied for the loom installation.

4. The take-off mechanism will be installed insofar as practical.

5. The outside warping and draw-in will be completed.

6. GAC will continue to monitor all phases of the loom construction and tests at Lansco plus the warping and draw-in procedure.

FIGURE 4
WINGFOOT LAKE FACILITY

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20	General Dynamics/Ft. Worth Attn: R. A. Fuhrer, Chief Mfg. Engr. P.O. Box 371 Fort Worth, Texas
21	Curtiss-Wright Corporation Attn: O. Podell, Vice Pres. Operational Planning 304 Valley Boulevard Wood-Ridge, New Jersey
22	Douglas Aircraft Co., Inc. Attn: N. H. Shappell Works Manager 3000 Ocean Park Boulevard Santa Monica, California
23	Fairchild Aircraft and Missile Division Attn: A. D. Jairett, Mgr. Tool Engr. & Mfg. Fairchild Airplane Corporation Hagerstown 10, Maryland
24	General Electric Company Missile & Space Vehicle Div. Attn: L. I. Chasen 3198 Chestnut Street Philadelphia 4, Pennsylvania

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26	Grumman Aircraft Engr. Corp. Attn: W. J. Hoffman, Vice-Pres. Mfg. Engineering Bethpage, L. I., New York
27	Lockheed Missiles & Space Co. Organization 73-01 Building 102 Attn: Dr. L. H. Ferrish P.O. Box 504 Sunnyvale, California
28	Lycoming Division AVCO Manufacturing Corporation Attn: W. H. Panke, Sup. Mfg. Engeering Stratford, Connecticut
29	Marquardt Corporation Attn: J. S. Liefeld, Dir. of Mfg. 16555 Saticoy Street Van Nuys, California
30	Pratt & Whitney Aircraft Div. of United Aircraft Corp. Attn: E. T. Seaward East Hartford 8, Connecticut
31	Northrop Corporation Norair Division 1001 East Broadway Hawthorne, California Attn: Technical Information, 3924-31
32	North American Aviation Rocketdyne Division Attn: C. W. Buckel, Supv. Methods Group Ind. Planning 6633 Canoga Avenue Canoga Park, California
33	Republic Aviation Corporation Attn: Mr. A. Kastelowitz, Dir. Mfg. Research Farmingdale, L. I., New York
34	Rohr Aircraft Corporation Attn: B. F. Raynes, Exec. Vice-Pres. P.O. Box 878 Chula Vista, California
35	Ryan Aeronautical Company Attn: R. L. Clark, Works Mgr. P.O. Box 311 Lindberg Field San Diego 12, California
36	Temco Aircraft Corporation Attn: E. F. Bushring, Plant Manager P.O. Box 1056 Greenville, Texas
37	Thompson Ramo Woolridge, Inc. Attn: C. W. Goldbeck, Asst. Staff Dir. Ind. Engr. 23555 Euclid Avenue Cleveland, Ohio
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55	Mr. J. H. Ross Fibrous Materials Branch, ASRCNF Directorate of Materials and Processes Wright-Patterson AFB, Ohio
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STRUCTURAL FABRIC PROGRAM, By
E. Bilsky and J. O. Miller
15 April 1963
pp. (Proj. 7-904)
(ASD TR 7-904 (VII)
(Contract AF33(600)-43036)

The purpose of this program, as related to Aerospace applications, is to provide a means of manufacturing large low-density AIRMAT* structures made of metallic cloth and yarns capable of small volume packaging.

1. Looms
2. Textiles
3. Metallic Cloth
4. AIRMAT*

I. E. Bilsky
II. J. O. Miller
III. Goodyear Aircraft Corp.
IV. Contract AF 33(600)43036
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